ECM 1.13.0 DESIGN GUIDELINES FOR SHORELINE MODIFICATION, STABILIZATION AND ACCESS

1.13.1 Introduction

This Section of Environmental Criteria Manual (ECM) is a resource document for the clarification and guidance of the minimum design criteria required to achieve compliant shoreline modification, stabilization and access as per Chapter 25-2, Subchapter C, Article 13 Sections 25-2-1171 through 25-2-1179, and compliant screening requirements for shoreline access as per Section 25-2-1066 of the City of Austin's (COA) Land Development Code (LDC). Requirements are established in subsections 1.13.4, 1.13.6, 1.13.7, and 1.13.8; resource and guidance are provided in subsections 1.13.5 and 1.13.9. These rules apply to the applicable development of the shores, banks and slopes of Lake Austin, Lady Bird Lake and Lake Walter E. Long.

As a resource document, subsections 1.13.5 and 1.13.9 provide several methods that, if used in the appropriate setting, should achieve compliant shoreline stabilization while minimizing wave return, promoting ecological function and maintaining the natural and traditional character of the lakeshore. However, these are in no way a complete exhaustive compendium of suitable methods. The specific methods selected by the applicant to satisfy the criteria included in this manual are the sole responsibility of the applicant and should be based on the constraints of the project area.

Any questions concerning the guidance or use of methods not included in this document should be directed to the Environmental Resource Management division, Watershed Protection Department. Methods of design other than those indicated in these rules may be considered in those cases where experience indicates they are appropriate. However, any variations from the methods established in these rules must have the express written approval of the Director of the Watershed Protection Department or the Director's designee.

Naturally vegetated and sloping shorelines provide ecosystem benefits including soil stabilization, wave abatement, pollutant removal, and habitat. Native riparian plants have both structural and physiological adaptations (Mitsch 1993) which stabilize the soils with extensive root systems that can increase the shear strength of soil by transferring shear stresses into tensile resistance (Gray and Sotir 1996). The increase in structural habitat complexity (which includes the roots, plant bodies and irregular surfaces of natural shorelines) results in an increase in dissipation of the kinetic energy of waves (Gabel et al. 2008). Wetlands are able to remove excess nutrients from the water, including nitrogen, phosphorus and organic carbon (National Research Council 1995), immobilize and remove toxins, such as heavy metals, including copper, lead and zinc (Hammer 1989) and reduce turbidity (Kahl 1993; Vestergaard and Sand-Jensen 2000). The surfaces of organic inputs from riparian plants in addition to the stems, leaves, and roots of wetland plants are colonized by microscopic life (Dodds 2002) which are the principal food source of many invertebrates (Baker and Orr 1986). This community establishes the foundation of a complex food web that fosters a healthy biological community. Vegetated and structurally complex shallow waters are utilized by juvenile fish as protective nurseries which provide shelter from predators and safe havens for foraging (Wiley et al. 1984; Killgore et al. 1989).

Although some degree of shoreline erosion is a natural process that sustains riparian ecology, accelerated erosion due to man-made influences can result in property loss and degradation of aquatic and terrestrial resources. These influences include, but are not limited to, increased wave action from recreational boating, removal of native shoreline vegetation and physical modification of the shoreline. The traditional approach to stabilize a shoreline has been to armor the bank with a vertical bulkhead. These rigid, vertical structures inhibit the potential benefits of natural shorelines and can create additional problems including the reflection of wave energy and increased wave action (Gabel et al. 2008), increased erosion of the lake bed (Herder 2007), increased turbidity (NOAA 2007), degradation of aquatic habitat (Engle and Pederson

1998), and removal of shoreline vegetation which can affect the productivity of aquatic biological communities (Kahler, Grassley and Beauchamp 2000). Although individual small changes to the environment may not significantly impact an ecosystem, the "cumulative effects of even small lakeshore alterations can lead to major ecosystem responses" (Burns 1991). The findings of the first National Lakes Assessment (NLA) conducted by the EPA indicate that "poor habitat condition along the lakeshore is the most significant stressor in lakes." The NLA suggests that local initiatives "should center on protecting shorelines habitats, particularly maintaining vegetative cover" (USEPA 2010).

1.13.2 Policy

A. Purpose and Intent.

Several recent studies have indicated a need to address both the results of wave action and protection of shoreline integrity. In 2005, following observations of wave action on various shorelines of Lake Austin, the Lake Austin Advisory Panel of the Lower Colorado River Authority (LCRA) recommended the disapproval of vertical, flat bulkheads unless several features were incorporated for the minimization of wave return. A report of recreational boating on Lake Austin by the LCRA, City of Austin and Texas A&M AgriLife has documented significant public concern about the negative effects of wave action on Lake Austin (Kyle et al. 2009). The first National Lakes Assessment (NLA) by the U.S.EPA has stressed the contribution to water quality and biological integrity of naturally functioning shorelines (USEPA 2010). In 2009 the City of Austin Parks Board, Environmental Board and Planning Commission supported an initiative to amend the code and criteria for the "prevention of vertical bulkheads and promotion of stable shorelines with materials and designs that provide the environmental function of native riparian vegetation and shoreline geomorphology." On December 9, 2010, the City Council approved amendments supporting the recommendations of the boards and commissions (Ordinance Number 20101209-075). The amendments became effective on December 20, 2010.

In order to protect public safety, property, water quality and ecosystem integrity, the intent of these rules is to provide criteria and guidance for code compliant shoreline development that promote the form, function and benefits of natural riparian ecosystems. The objectives include providing examples of shoreline stabilization methods which minimize wave return by protecting and/or establishing vegetated, sloping shorelines, and identifying methods to protect the integrity of steep slopes with native vegetation.

B. Plans and Computations.

Plans and computations to support all shoreline modification and access designs shall be submitted to the Planning and Development Review Department for review. The Staff review period for preliminary plan approval is described in LDC § 25-4-56. Plans and computations shall be in such form as to allow for timely and consistent review and to be made a part of the permanent record for future reference. The reviewer may deny an application if the applicant cannot support designs with appropriate calculations. All engineering computations shall be certified by a Professional Engineer licensed in the State of Texas.

1.13.3 Definitions

Bioengineering - A system of living plant materials used as structural components to restore stability and establish a vegetative community (U.S. Department of Agriculture, 1996).

Biotechnical Stabilization - Mechanical elements (or structures) in combination with biological elements (or plants) to arrest and prevent slope failures and erosion (Gray and Sotir, 1996).

Boat Ramp – A hardened or paved surface designed and constructed to provide for the launching and retrieving of trailered boats and personal water craft to and from a body of water.

Drainage Fill - Aggregate placed behind the bulkhead to reduce or eliminate hydrostatic pressure.

Filter Fabric - A geotextile used to retain (1) the soil particles while (2) providing a zone for the free flow of water through the interface between the riprap armor and the underlying soil (Lagasse et al., 2006).

Flanking - Erosion of shoreline on either side of a shoreline protection measure (USDA, 1997).

Granular Filter Material - An aggregate filter layer used to (1) retain the soil particles while (2) providing a zone for the free flow of water through the interface between the riprap armor and the underlying soil (Lagasse et al., 2006).

Lakeshore Vegetation Buffer Zone – The Lakeshore Vegetation Buffer Zone is the area that native and adapted riparian vegetation plantings are to be planted as per the requirements of ECM 1.13.6(C). The landward boundary of this zone is ten feet inland horizontally from the shoreline. The lakeward boundary of this zone extends to the topographic contour of one foot in depth vertically from the normal pool elevation. See Figure 1.13-1a.

Scour Depth – Depth at which hydrodynamic bottom shear stresses are greater than sediment critical shear stress resulting in scour, or removal of granular bed material by hydrodynamic forces.

Significant Wave Height - Average wave height for the highest one-third of waves for a specified period of time (USDA, 1983). A reasonable assumption for shorelines that face the centerline of Lake Austin is 1.5 feet. See Figure 1.13-1b.

Toe – The break in slope at the foot, or bottom of a bank, where it meets the lakebed.

Toe Protection- Submerged materials that are sized to resist movement and/or erosion of lakebed by hydrodynamic forces such as wave action.

Wave Action Zone – The zone that extends from the depth at which wave-induced water movement is negligible (1/2 wavelength) to the landward extent of the height of wave run-up. A reasonable assumption for the depth at which water movement is negligible for shorelines that face the centerline of Lake Austin is a depth of four feet. See Figure 1.13-1b.

Wave Height - Wave height is the vertical distance measured from trough to crest (USDA, 1983). Observations of the LCRA Lake Austin Advisory Panel on Lake Austin indicate that a reasonable assumption for wave height is 1.5 feet (Crowther, personal communication, September 2, 2005). See Figure 1.13-1b.

Wavelength - The horizontal distance between similar points on two successive waves measured perpendicularly to the crest (USDA, 1997). Observations of the LCRA Lake Austin Advisory Panel on Lake Austin indicate that a reasonable assumption for wavelength is 12 feet (Crowther, personal communication, September 2, 2005). See Figure 1.13-1b.

Wave Run-up – The vertical distance above the normal pool elevation (as defined in LDC 25-2-1172) that a wave will run up the slope of a shore as it dissipates its energy. The USDA Natural Resource Conservation Service (NRCS) provides technical guidance for calculating wave run-up in Slope Protection for Dams and Lakeshores (USDA, 1997). See Figure 1.13-1b and Figure 1.13-1c.

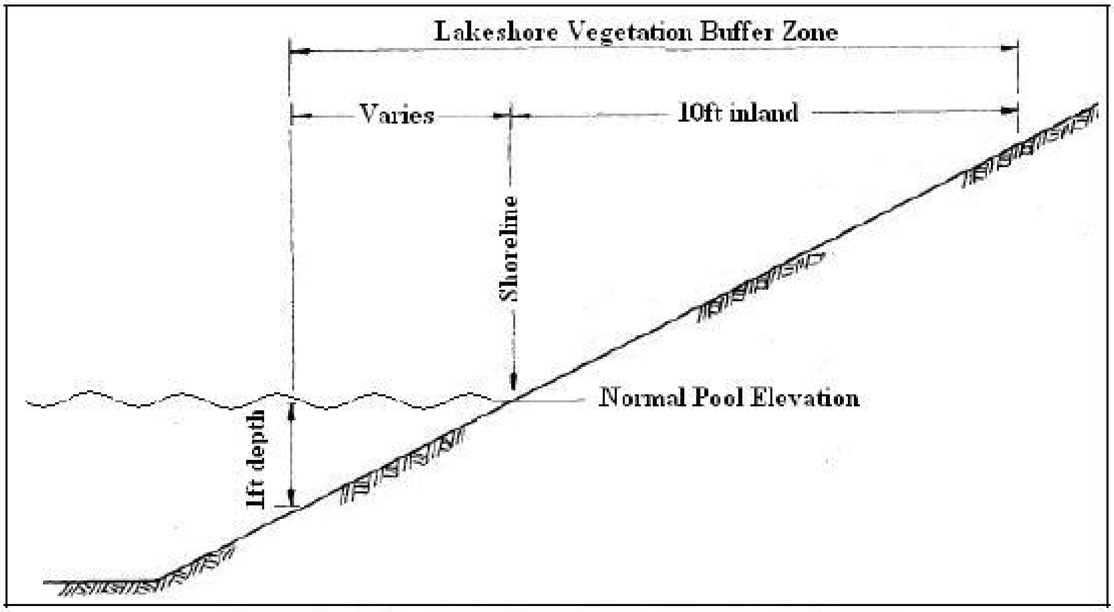


Figure 1.13-1a. Lakeshore Vegetation Buffer Zone.

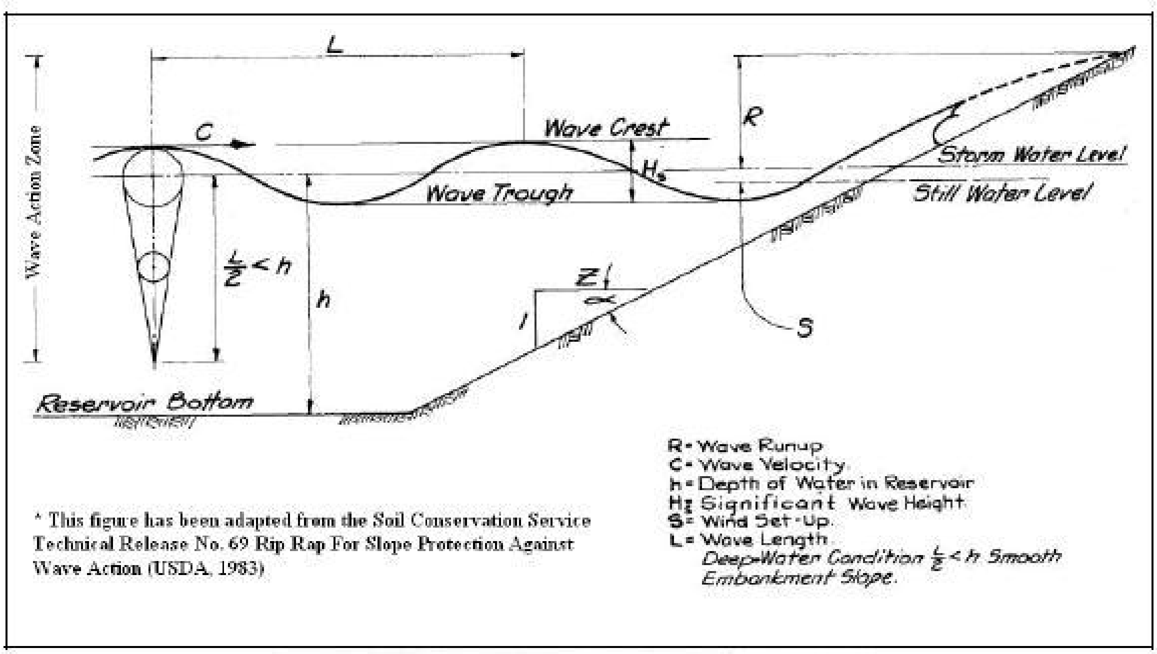


Figure 1.13-1b. Wave Runup and Wavelength.

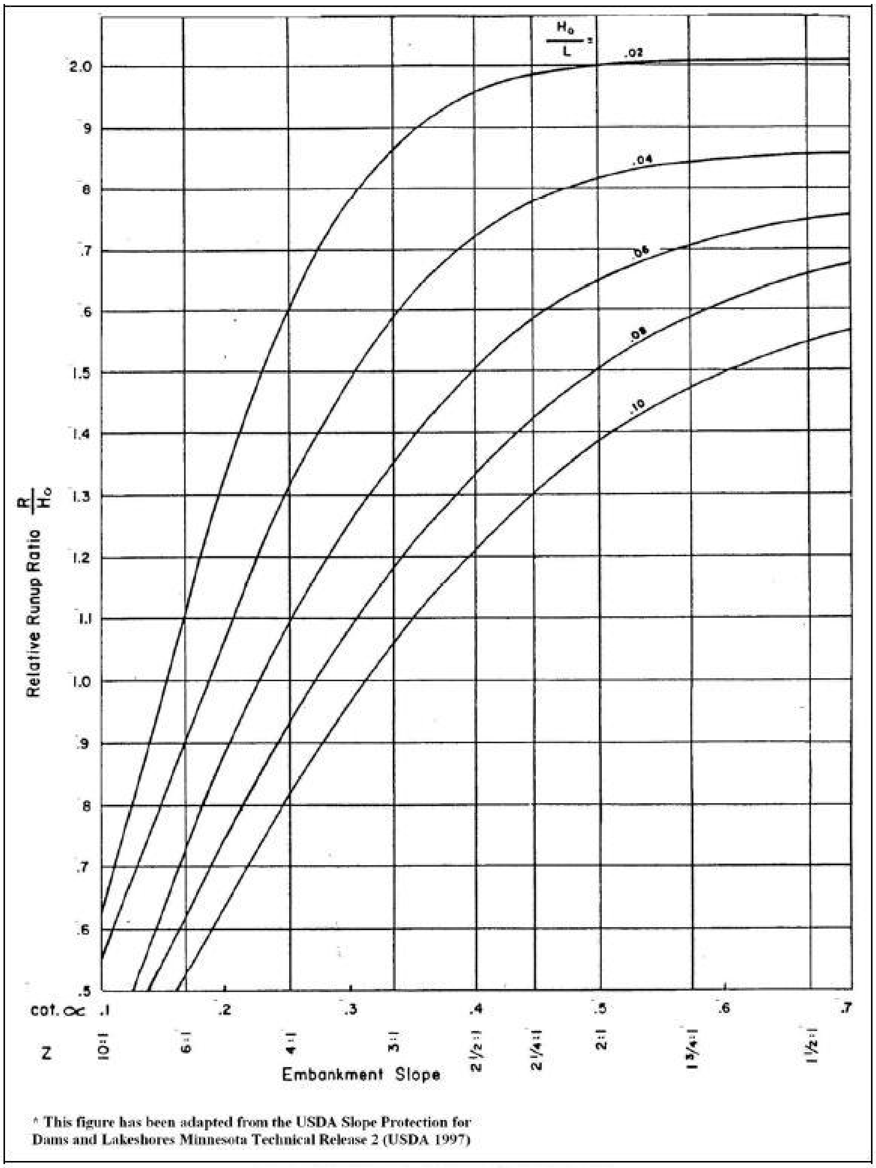


Figure 1.13-1c. Wave Runup Ratio.

1.13.4 Identification Tag Required for Dock and Erosion and Sedimentation Controls

A. Guidance for Identification Tag Required for Dock.

Identification or registration tags shall be placed on the dock by an applicant as part of the requirements for a permit for construction of a dock as per LDC 25-2-1173(B). The identification or registration tag shall consist of the street address of the property on which the dock is located and shall be displayed on the lakeward side of the dock facing the centerline of the lake or slough on which it is located. The letters and numbers must be at least two inches in height and be constructed with materials that resist water damage and deterioration by ultraviolet light.

B. Erosion and Sedimentation Control.

Implementation of effective erosion and sedimentation controls should demonstrate the scope and intent of Section 1.4.4(A) of the ECM for shoreline development and shoreline access. Temporary construction disturbance to upland soils should be stabilized with City of Austin approved controls (see Section 1.4.5) and temporary construction disturbance to lake bed substrate should be stabilized with practices appropriate to the constraints of the project area such as silt booms, temporary coffer dams or coconut fiber rolls to be installed as per manufacturer specifications. The applicant must post fiscal surety for erosion and sedimentation controls in accordance with ECM Section 1.4.4 (C).

1.13.5 Recommended Guidance for Appropriate Method for Shoreline Stabilization and Modification

A. Guidance for Method Selection.

Depending on the size and scope of the proposed shoreline stabilization or modification, it is recommended to work with a qualified professional or team of professionals. This may include retaining the services of an appropriately qualified biologist, hydrologist, and/or civil engineer, in order to assess and manage the dynamics of the shoreline erosion problem. The scope of the project should be evaluated in the context of LDC 25-7-62 to determine if the site plan is required to be accompanied by a certificate bearing the seal of a Texas professional engineer.

An evaluation of existing site characteristics should be performed prior to determining the appropriate method for shoreline stabilization. These characteristics include surface runoff, near-shore bathymetry, site topography, soil composition, vegetation, wave run up, hydrology and slope stability. It is recommended that selection of the appropriate method that meets the intent of this section should be determined by a licensed engineer.

Selection of appropriate methods for shoreline stabilization should consider the following factors:

- Soil characteristics of banks and bed of shoreline.
- Proximity to and constraints of Critical Environmental Features (CEF's) such as wetlands, springs, caves, rimrocks and bluffs.
- Existing lakeshore morphology.
- Potential access related to construction or future repair or maintenance of the structure.
- Minimizing impacts to riparian vegetation and/or fish and wildlife habitat.
- Erosion dynamics of the shoreline (i.e., what is causing the problem).
- Appropriate temporary and permanent erosion and sedimentation controls.

- Location along the lake (i.e., is the location in a low or high energy environment).

In the case of shoreline stabilization and modification, work should only be undertaken when the need for such work can be justified by the level of risk to existing buildings, roads, services or property that are being threatened by erosion. Shoreline stabilization methods include non-structural, hybrid and structural. The shoreline stabilization method should be appropriate for the conditions of the site. Table 1.13-1 provides guidance for the selection of shoreline stabilization method.

Table 1.13-1 Shoreline Stabilization Method Selection Guidance			
Hydraulic Energy Environment	*Low Energy*	*Medium Energy*	*High Energy*
Shoreline Location	*Backwater coves and sloughs*	*Cove/slough mouths or Lakeshores facing centerline of lake with shallow slopes in the nearshore*	*Lakeshore facing centerline of lake with steep slopes in the nearshore*

Exposure and Proximity to Boat Traffic	*Low*	*Moderate*	*High*
Water Depth Within Four Feet of Shoreline	*< 1 foot*	*1 to 4 feet*	*>4 feet*
Preferred Shoreline Stabilization Method	*Non-Structural Methods*	Hybrid Methods (vegetation plantings in Lakeshore Vegetation Buffer Zone as per 1.13.6(C))	Structural Methods (vegetation plantings in Lakeshore Vegetation Buffer Zone as per 1.13.6(C))

B. Non-Structural, Hybrid and Structural Methods.

1. Non-Structural Methods.

Non-structural methods are recommended in areas which are buffered from, or located above, the forces of strong current or wave action. They can also be used in conjunction with hybrid or structural methods described below for portions of projects above the wave runup elevation. Non-structural methods are primarily a combination of native and adapted vegetation with natural, biodegradable materials, generally including coconut fiber rolls, wattles, and /or mattresses, but can also include live fascines, live stakes, branch packing, live cribwalls, joint plantings, and brush mattresses as described in part 650 of the Engineering Field Handbook (USDA, 1996) and Part 654 of the National Engineering Handbook (USDA 2007). Examples of non-structural methods are included in Section 1.13.9.

Shoreline stabilization strategies are preferred that utilize native vegetation and biodegradable materials to enhance the integrity of the shoreline and do not concurrently alter the shoreline, remove existing native vegetation, disturb soils, involve the placement of fill in the lake, hard-armor the shoreline, or otherwise constitute development as defined by LDC 25-1-21. Activities that meet these constraints may not require a site plan as per LDC 25-5-1, and are encouraged if sustainable. First consideration should be given to the appropriateness of these non-structural stabilization methods for any shoreline stabilization project.

2. Hybrid Methods.

If site conditions do not permit the exclusive use of non-structural methods, then a hybrid method should be used for shoreline stabilization including bioengineered or biotechnical stabilization methods. Hybrid methods use soft armor materials such as vegetated, fabric encapsulated soil (FES) lifts above the wave runup height and hard armored materials such as appropriately-sized rock riprap in the wave action zone. Hybrid methods also include vegetated, graded slope with rock riprap toe protection and FES lifts with a stacked limestone boulder toe protection. Figures illustrating various hybrid methodologies are included in Section 1.13.9.

Structural components such as pilings, concrete and metal sheet piles may constitute portions of the internal components of the hybrid structure but not external portions as per the examples in Section 1.13.9. Native and adapted vegetation plantings are incorporated into the stabilization strategy to be located within in the boundaries of the Lakeshore Vegetation Buffer Zone as per the requirements of ECM Section 1.13.6(C).

3. Structural Methods.

If site conditions present extreme characteristics, such as vertical bathymetry or man-made channels, purely structural methods may be approved if they meet the general requirements of this section. Structural methods include metal sheet piles as internal components of a bulkhead and rock walls as external components. The exclusive use of structural methods is discouraged unless dictated by extreme site constraints. Structural methods must still demonstrate compliance with the design and materials described in this section. Structural methods will require native and adapted vegetation plantings in the Lakeshore Vegetation Buffer Zone as per the requirements of ECM Section 1.13.6(C) to maintain the natural and traditional character of the waterway.

C. Selection Limitations.

The methods appropriate for high energy environments such as structural hard armoring may not be appropriate for use in low energy environments or within the boundaries of CEF's, unless the applicant can demonstrate and submit calculations supporting a reasonable and appropriate need for such methods. First consideration must be given to non-structural methods. If non-structural and hybrid methods are not proposed, the applicant must demonstrate that site conditions present extreme circumstances commensurate with structural methods. Extreme circumstances include, but are not limited to, steeply descending slopes below the normal high water mark which result in depths that would otherwise result in the potential discharge of greater than an average of one cubic yard of fill per running foot along the bank below the plane of the ordinary high water mark.

1.13.6 Design and Material Requirements for Hybrid and Structural Lakeshore Stabilization.

As per LDC 25-2-1174(C) a retaining wall, bulkhead, or other erosion protection device must be constructed using design and materials prescribed by rule. The following design and material criteria have been developed with the purpose and intent of the promotion of non-vertical, stable shorelines that provide wave abatement as well as provide the environmental function of native riparian vegetation and shoreline geomorphology. Retaining walls, bulkheads and other erosion protection devices that do not exclusively utilize a non-structural method as described in 1.13.5(A)(1) must demonstrate the following design and material criteria:

A. Non-Vertical Slope.

The shoreline stabilization method shall not exhibit vertical slopes steeper than 1H:1V (45 degrees) in the wave action zone for any portion greater than one foot in height. As per LDC 25-2-1174, this requirement does not apply to existing man-made channels. For the purposes of this section only, man-made channels are those areas which were wholly and completely uplands prior to excavation for navigational purposes, but do not include areas which were expansions or excavations of pre-existing wetlands or waterways.

B. Protection From Overtopping, Toe Scour and Flanking.

The shoreline stabilization method shall not inherently cause erosion of the upper bank, lakebed or adjacent shoreline. A more thorough explanation of overtopping, toe scour and flanking with design considerations and figures is provided in Slope Protection for Dams and Lakeshores (USDA 1997).

1. Overtopping - The shoreline stabilization method provides overtop protection to the maximum extent of wave runup on the upper bank. Wave runup can be reduced by using a cap that extends from the top of the bulkhead or by providing a layer of stable horizontal or sloped materials on which wave run-up can be dissipated.

2. Toe Scour Protection - The shoreline stabilization method must provide toe protection of the slope which is embedded to a depth that is greater than the maximum scour depth of the lake bed calculated based on site specific characteristics.

3. Flanking - The shoreline stabilization method must provide protection of the adjacent shoreline from flanking by demonstrating that the ends of the structure resist erosion with tiebacks or return walls.

C. Vegetation Plantings for Wave Abatement and Stabilization.

Riparian vegetation plantings as per the criteria within this subsection are required for shoreline modification and/or shoreline stabilization as part of the comprehensive design and materials for shoreline stabilization and/or wave abatement. Native and adapted emergent wetland plants provide wave abatement, shade and cover for fish, microhabitats for invertebrates, stabilization of the soft bottom sediments and sequestration of pollutants. Riparian vegetation of the lower and upper banks provide soil stabilization, erosion protection from overland flow, nutrient removal, shading and organic inputs for aquatic life. Together, the aquatic and riparian vegetation perform critical functions in the stability and ecological function of the lakeshore. To maximize the success of vegetation plantings, it is recommended that the applicant consult a landscape architect or similar professional specializing in wetland plants to determine site-specific considerations including location, planting method, temporary irrigation or temporary protection from wave action. In addition, shoreline stabilization measures should maintain existing shoreline vegetation to the maximum extent practicable and provide 1:1 mitigation for unavoidable loss of herbaceous and woody vegetation. The applicant must demonstrate the posting of fiscal surety for revegetation as part of the permanent erosion and sedimentation control strategy.

The plants in Table 1.13-2 include an assortment of native and adapted riparian species from which a selection can be made to offset any difficulty in acquiring any particular specie due to variability in commercial availability. The vegetation specifications of a site plan proposing shoreline modification or stabilization must:

1. Incorporate the planting of mature specimens of riparian, native and adapted vegetation and identify the quantity, size, species and location of all plantings in the site plan. Approved species are listed in Table 1.13-2, however, alternative native and adapted species can be approved by the PDR Environmental Reviewer, ERM Wetland Biologist or ERM Landscape Architect. Plantings shall be located within the Lakeshore Vegetation Buffer Zone as defined in Section 1.13.3.

2. Demonstrate the appropriate quantities of plantings commensurate with shoreline modification and extent of impact. The exclusive use of non-structural methods (as per Section 1.13.5) exempts the applicant from quantity requirements, however, recommended quantity is 1gallon containers on three foot centers. Minimum required planting quantities for Hybrid methods (as per Section 1.13.5) shall be either one plant (of 1-gallon containerized or equivalent) per 20 square feet of LOC or one plant (of 1-gallon containerized or equivalent) per 3 running feet of shoreline modified. Planting quantities for Structural methods (as per Section 1.13.5) shall be two plants (of 1-gallon containerized or equivalent) per 20 square feet of LOC or two plants (of 1-gallon containerized or equivalent) per 3 running feet of shoreline modified. Equivalency ratios are as follows:

- One 1-gallon container = two 1-quart size.
- One 1-quart size = one 4-inch container.
- One 4-inch size = four bare root specimens.

3. Specify that plants do not include invasive species and be sourced from within a 200 mile radius of Austin.

4. Achieve a minimum diversity of 3 species required for projects impacting less than 100 linear feet of shoreline, and a minimum of 5 species required for larger projects.

5. Demonstrate utilization of approved species as per Table 1.13-2 or documentation of approval of alternative native and adapted species as approved by the PDR Environmental Reviewer, ERM wetland biologist or ERM landscape architect.

Table 1.13-2 Shoreline vegetation planting guidance[1] for Austin-area lakes

Location	Common Name	Botanical Name
Shallow water (0-½ft below normal pool)	American water willow	Justicia americana
Shallow water (0-½ft. below normal pool)	Delta arrowhead	Sagittaria platyphylla
Shallow water (0-½ft. below normal pool)	Three-square bulrush	Scirpus americanus
Shallow water (0-½ft. below normal pool)	Pickerelweed	Pontederia cordata
Shallow water (0-½ft. below normal pool)	California bulrush	Schoenoplectus californicus
Location	Common Name	Botanical Name
Lower Bank (0-1ft above normal pool)	Horsetail	Equisetum laevigatum
Lower Bank (0-1ft above normal pool)	Beaked Spikerush	Eleocharis rostelata
Lower Bank (0-1ft above normal pool)	Sand Spikerush	Eleocharis montevidensis
Lower Bank (0-1ft above normal pool)	Emory Sedge or Frank’s Sedge	Carex emoryii or Carex frankii
Lower Bank (0-1ft above normal pool)	Blue Flag Iris	Iris virginica or fulva
Lower Bank (0-1ft above normal pool)	Cardinal flower	Lobelia cardinalis
Upper Bank	Bushy bluestem	Andropogon glomeratus

(1-4ft above normal pool)		
Upper Bank (1-4ft above normal pool)	Big Muhly	Muhlenbergia lindheimeri
Upper Bank (1-4ft above normal pool)	Buttonbush	Cephalanthus occidentalis
Upper Bank (1-4ft above normal pool)	Deciduous holly	Illex decidua
Upper Bank (1-4ft above normal pool)	Native Carex sedges	Carex cherokenesis Carex perdentada Carex blanda Carex levenworthii
Upper Bank (1-4ft above normal pool)	Eastern Gama grass	Tripsacum dactyloides
Upper Bank (1-4ft above normal pool)	Bald Cypress	Taxodium distichium

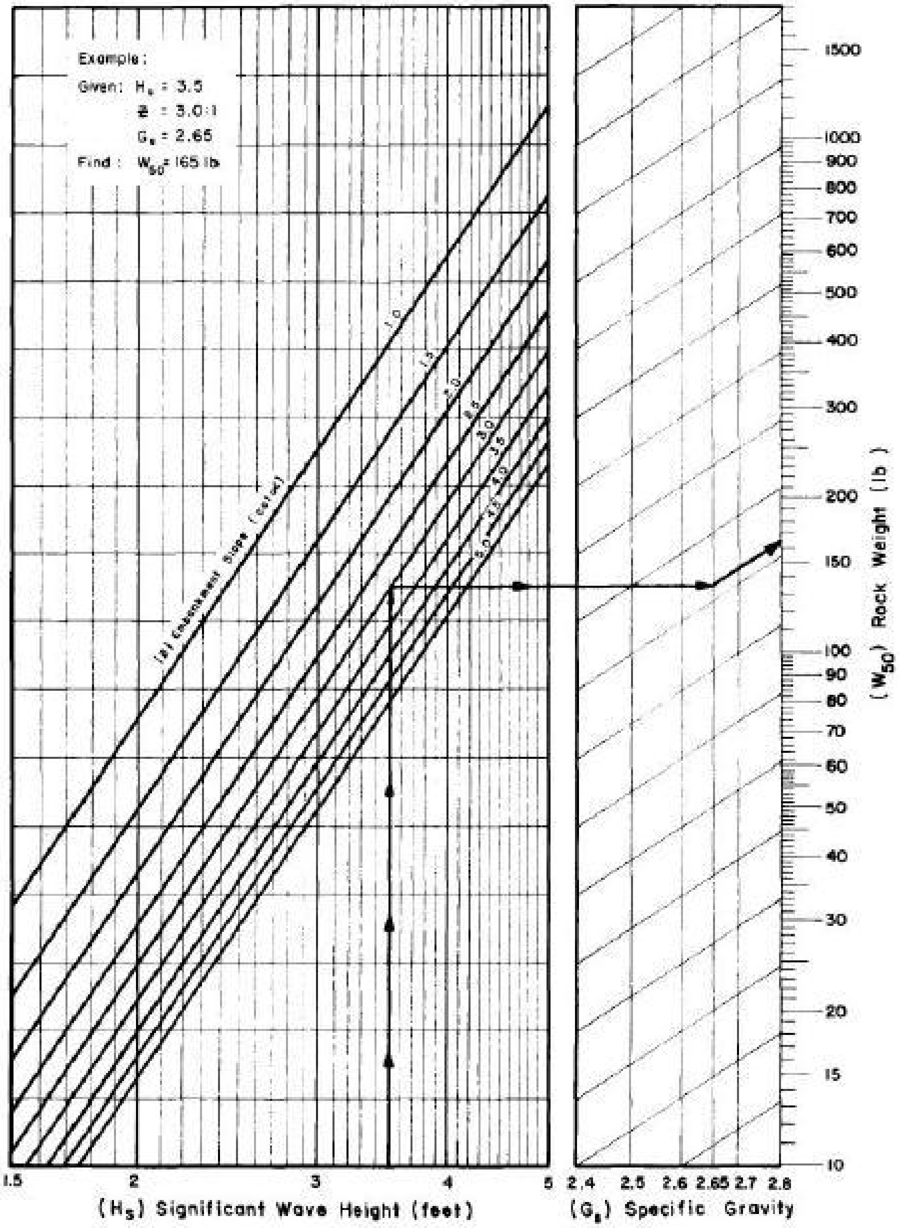
[1] Alternative native and adapted species may be substituted with the same quantity of another species as approved by the PDR Environmental Reviewer, ERM Wetland Biologist or ERM Landscape Architect.

D. Materials.

External components must be composed of natural, non-toxic materials (such as stone, rock rip rap, wood, sand, plants and/or bioengineered textiles that support the growth of vegetation) that preserve the natural and traditional character of the waterway (see LDC 25-7-61(A)(5)(b)) and minimize damage to the physical and biological characteristics (see ECM 1.7.7(A)). Internal structural components may include non-natural materials such as concrete and/or corrosion resistant steel and aluminum pilings, metal sheet piles, anchors and fasteners as necessary. Materials approved for the external components include:

1. Rock Riprap. Riprap is a layer, facing or protective mound of stone strategically placed to protect the shoreline from erosion. Rock riprap conforming to Standard Specification Item No. 591S, "Riprap for Slope Protection" for dry riprap, may be used for bank protection. When the riprap will be placed on an erodible soil, as determined by the Engineer or designated representative, a layer of filter fabric or granular filter material shall be placed, prior to placement of the Riprap material. Filter fabric conforming to Standard Specification Item No. 620S, "Filter Fabric", may be used for bank protection. Rock Riprap shall be of sufficient size(s), layer thickness, gradation, vertical extent and slope to demonstrate stability under expected conditions. Riprap on a shoreline shall be sized appropriately for the weight, specific gravity and slope for a given wave height according to the Rock Size Selection method in Figure 1.13-2 (see also USDA 1983). Additional guidance for riprap in lake and stream environments is provided in Slope Protection for Dams and Lakeshores (USDA 1997), Design of Coastal Revetments, Seawalls and Bulkheads (USCOE 1995), Bridge Scour and Stream Instability

Countermeasures: Experience, Selection, and Design Guidance (Federal Highway Administration 2009), ECM Section 1.4.6, Design of Riprap Revetments (Federal Highway Administration 1989), Riprap Design Criteria, Recommended Specifications and Quality Control (NCHRP 2006), and Loose Riprap Protection (USDA 1989).



$$W_{50} = \frac{19.5 \; G_s \; H_s^3}{(G_s - 1)^3 \; \cot \alpha}$$

* This figure is adapted from the Soil Conservation Service Technical Release No. 69 Rip Rap For Slope Protection Against Wave Action (USDA, 1983)

Figure 1.13.-2. Rock Size Selection

2. Soil Retention Blanket (SRB). SRB conforming to Standard Specification Item No. 605S, "Soil Retention Blanket", may be used for bank protection.

3. Coconut (Coir) Fiber rolls and mattresses. Coconut rolls and mattresses shall be manufactured from 100 percent mattress grade, non-sorted coconut fiber and encased in 100 percent coconut fiber mesh netting. Fiber interior of rolls shall be tightly packed into the mesh and have a minimum density of 7 pounds per cubic foot. Mesh shall have approximately 2 inch rhombic or square mesh openings with mesh junctions tied. Tensile strength per hand or machine yarn shall be 90 pounds when dry. Each coconut roll shall have a minimum diameter equal to 12 inches. Coconut fiber rolls and mattresses should be installed and anchored as per manufacturer specifications for site specific conditions.

4. Structural Geogrids. Structural geogrids shall consist of a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock or earth and function primarily as reinforcement. Geogrids used for bank protection shall conform to Standard Specification Item No. 607S, "Slope Stabilization for Erosion Control". Material selection is site specific and it is the responsibility of the Engineer to determine the appropriate material for project.

5. Boulders. Boulders used for bank protection shall conform to Standard Specification Item No. 623S, "Dry Stack Wall". Boulders shall be durable weathered field stone of suitable quality to promote longevity in the structure. Boulders shall be comprised of solid rock without excessive fractures, spalls, or weak layers, and shall have a minimum specific gravity of 2.1. Boulders shall be described as either "Natural Boulders" or "Cut Boulders."

a. Natural Boulders should be irregular in shape with a rough surface on all edges. No edges of the boulders shall be saw cut. If boulders are to be stacked, the top and bottom of the units shall be approximately parallel. Boulders shall be relatively uniform in height (minimum dimension) and within 15% of the dimensions specified. The length dimension may vary, but should be greater than or equal to two times the height dimension. The width dimension may vary but should be greater than or equal to 1.5 times the height dimension (Figure 1.13-3a).

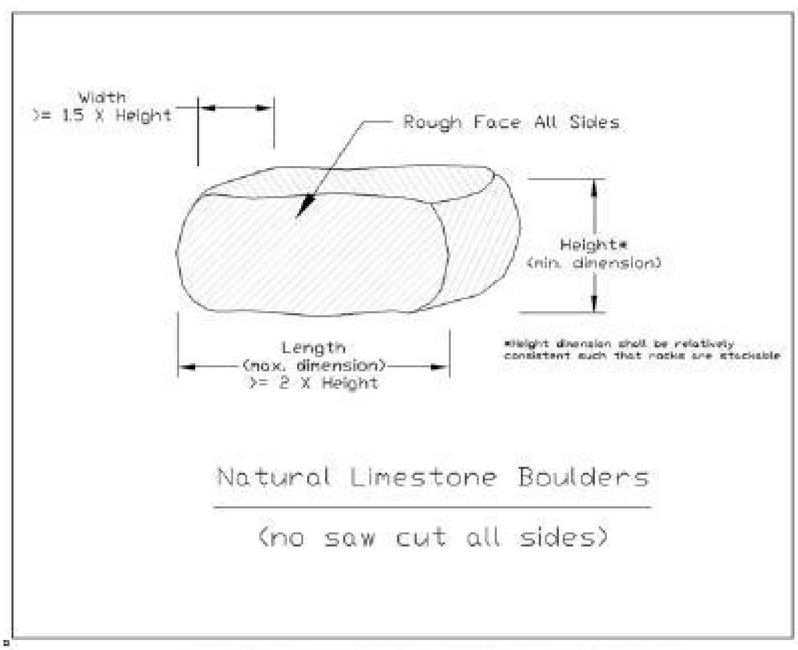


Figure 1.13-3a. Natural Boulder Detail

b. Cut Boulders may have a rough surface on the face, but shall be relatively rectangular. The top and bottom of the units shall be parallel so that they are stackable. Boulders shall be uniform in height and within 8% of the dimensions specified. The split rough face (uncut) of the boulder shall be on the side with the plane created by the minimum dimension (height) and the longest dimension (length) as shown in Figure 1.13-3b.

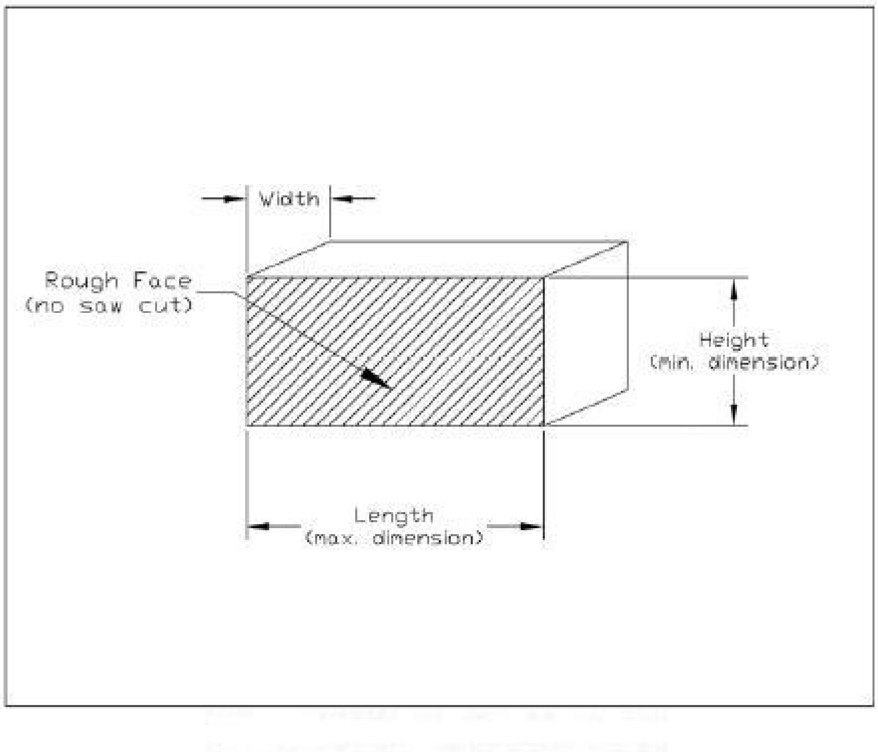


Figure 1.13-3b. Cut Boulder Detail

6. Topsoil. Topsoil used for bank protection shall conform to Standard Specification Item No. 601S, "Salvaging and Placing Topsoil".

7. Alternative Materials. Alternative materials may be approved on a case-by-case basis by the PDRD Environmental Reviewer or WPD Environmental Resource Management Reviewer.

1.13.7 Vegetation for Screening and Slope Stability of Shoreline Access

A. Vegetation for Screening and Slope Stability.

Protection and maintenance of the herbaceous and woody vegetation of steep canyon slopes resists erosion, reduces sediment-laden runoff and maintains natural and traditional character. Site plans must demonstrate the screening of shoreline access, as required by LDC 25-2-1066(B) and environmental protection of vegetation as required by LDC 25-2-1179(D) during development of shoreline access by:

1. Maintaining the natural herbaceous and woody vegetation cover to the maximum extent practicable while avoiding the removal of any existing canopy; and

2. Locating the shoreline access under existing canopy coverage to the maximum extent practicable; and

3. Providing 1:1 mitigation for the clearing of woody and herbaceous vegetation in instances where impacts to vegetation are unavoidable, with native seeding with 604S.6 for temporary stabilization

hydromulched (as per ECM 1.4.7) and native and adapted woody and herbaceous plantings (1 gallon containers) on ten foot centers. Recommended woody and herbaceous plantings are presented in Table 1.13-4; and

4. Providing temporary irrigation and biodegradable erosion controls such as coconut fiber logs or mulch socks which provide stable substrate for plant growth during initial establishment; and

5. Demonstrating the utilization of recommended species or documentation of approval of alternative native and adapted species as approved by the PDR Environmental Reviewer, ERM wetland biologist or ERM landscape architect; and

6. Providing supplemental compliance as per 1.13.7(B) if one or more of preceding requirements are not feasible.

Table 1.13-4 Recommended plants[1,2] for upland canyon slopes.

Common Name	Botanical Name	Comments
Devil's Shoestring	Nolina lindheimeriana	bunchgrass
Basket grass	Nolina texana	bunchgrass
Meadow Sedge	Carex perdentata	sedge
Texas Mountain laurel	Sophora secundiflora	evergreen shrub/small tree
Silktassel	Garrya ovata spp. lindheimeri	evergreen shrub
Evergreen sumac	Rhus virens	shrub
Blackfoot Daisy	Melampodium leucanthum	wildflower
Texas Persimmon	Diospyros texana	evergreen shrub/small tree
Evergreen Yaupon	Illex vomitoria	evergreen shrub/small tree

[1] Alternative native and adapted species may be substituted with the same quantity of another species as approved by the PDR Environmental Reviewer, ERM wetland biologist or ERM landscape architect.

[2] Consultation with a landscape architect or botanical professional is recommended to determine appropriate placement of plantings and specifications for a temporary irrigation plan.

B. Supplemental Compliance.

As provided by LDC 25-2-1066(B), a person may supplement compliance as described in 1.13.7(A) with other screening methods prescribed by rule. Supplemental compliance includes the coloration of all portions of the Shoreline Access structure with a dark, non-reflective color that hides, camouflages or blends the structure into the surrounding natural character of the canyon slope. Paint type should be appropriate to the material applied and should be of sufficient durability to resist flaking and chipping under normal conditions. As part of the condition of approval of supplemental compliance, the landowner is responsible for the upkeep and maintenance of coloration of the structure.

1.13.8 Additional Permitting Considerations for Shoreline Development

A. Land Capture Prohibited.

Shoreline stabilization materials including non-structural methods, bulkheads, rip-rap revetments and boulders that are not in excess of the minimum needed for erosion protection are not considered the capturing of land and are therefore permitted to be placed beyond the existing shoreline. As per LDC 25-2-1174(D), backfill for the purposes of land capture or reclamation may not exceed the extent of the existing shoreline unless capturing, or recapturing the land is required to restore the land to the lesser of: "the shoreline as it existed 10 years from the date of application, with documentation as prescribed by rule, or the lakeside boundary of the subdivided lot line." In the event that acceptable historical documentation of the shoreline is not provided, the subdivided lot line will not be assumed to be the lesser of the two, and therefore shall not be used to determine the limits of land capture. Acceptable historical documentation of the shoreline includes:

1. Two land surveys certified by a professional surveyor registered in the State of Texas; a current survey showing the location of the shoreline and a historical survey, preferably within 10 years, showing the location of the shoreline; and

2. Georeferenced aerial photography in which the shoreline in question is in plain view and not obscured by canopy, dense brush, photographic aberrations and glare; and

3. Tree surveys documenting historical and current locations of trees.

B. Boat Ramps Prohibited.

As per LDC 25-2-1176(I), construction of a boat ramp as defined in Section 1.13.3 is prohibited.

1.13.9 Resource Guidance for Shoreline Modification

The figures provided in this section are adaptations of nationally recognized methods for bank stabilization and are intended for guidance purposes only to demonstrate stabilization methods which are consistent with the requirements described in this section. The figures in this section are not requirements for shoreline modification and are not intended for use as construction documents. The applicant and/or engineer assume the responsibility for appropriate use of selected method.

Resources providing additional information for consideration of shoreline modifications and non-structural, hybrid and structural alternatives are available on-line and include: *The Shoreline Stabilization Handbook* (Northwest Regional Planning Commission 2004), *Streambank and Shoreline Protection* (USDA 1996), *Slope Protection for Dams and Lakeshores* (USDA 1997), *Green Shorelines* (City of Seattle 2008), *Shore Erosion Control - The Natural Approach* (Luscher and Hollingsworth 2005) and *The construction, aesthetics, and effects of lakeshore development: a literature review* (Engel and Pederson 1998).

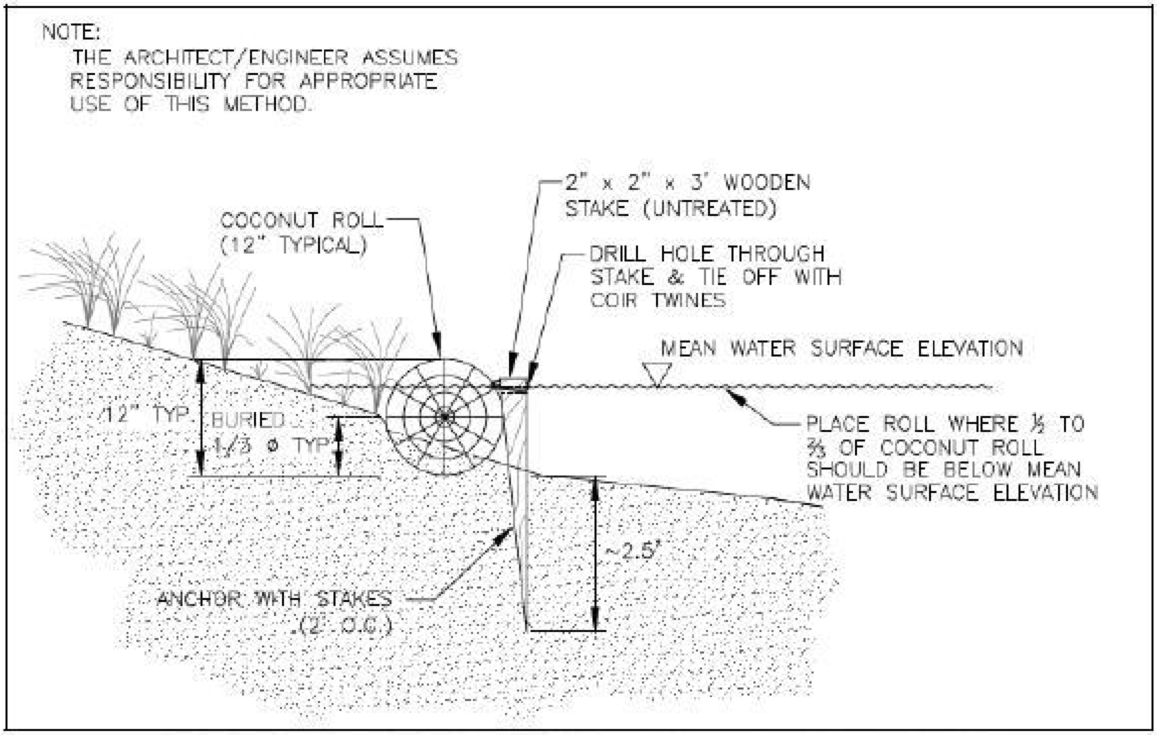


Figure 1.13-4a Shoreline Coconut Roll (12" Typical) Installation

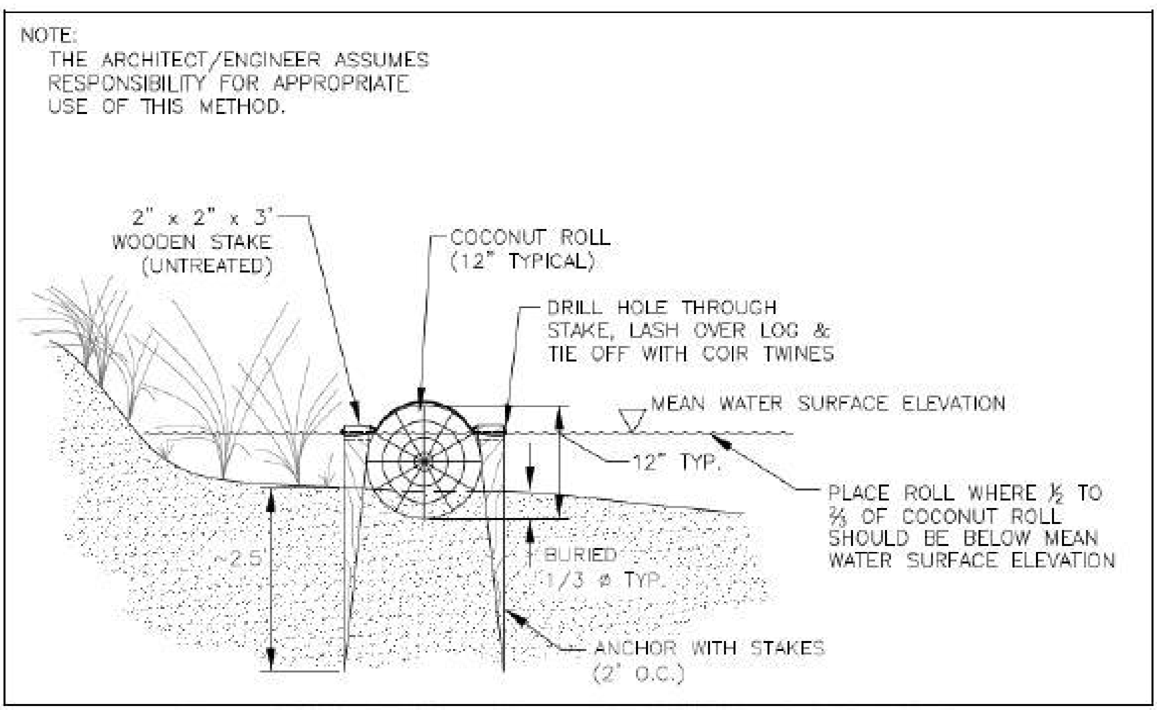


Figure 1.13-4b Shoreline Coconut Roll (18" Typical) Installation

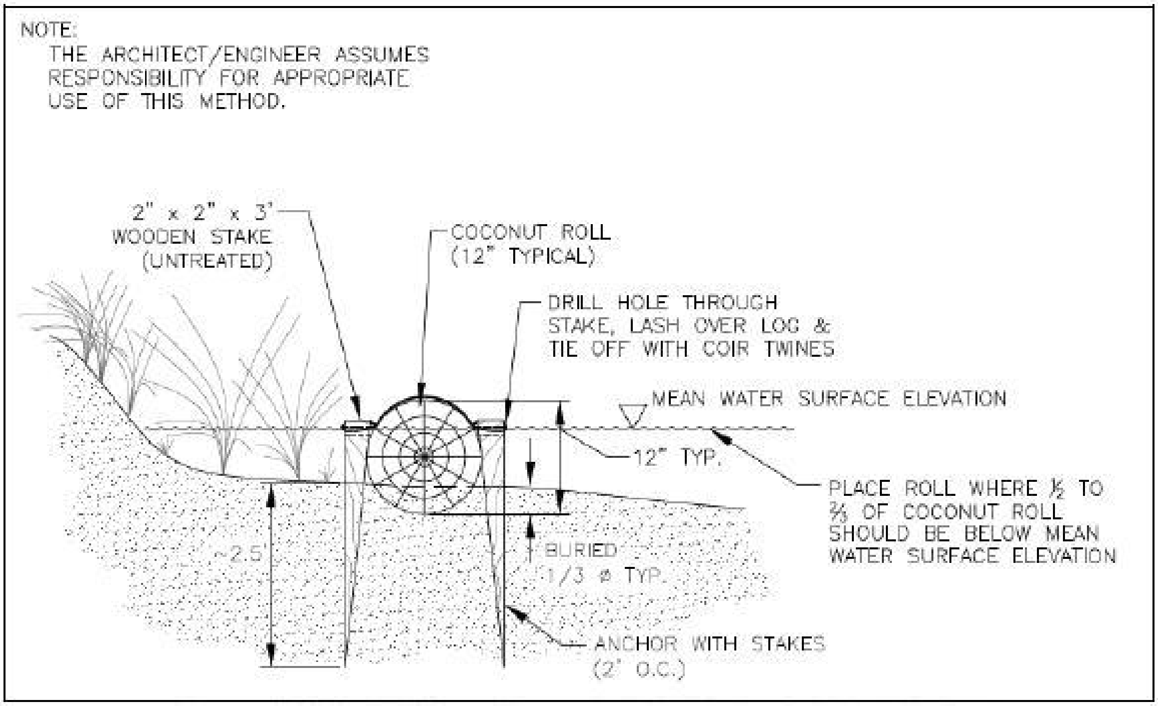


Figure 1.13-5a Offshore Coconut Roll (12” Typical) Installation

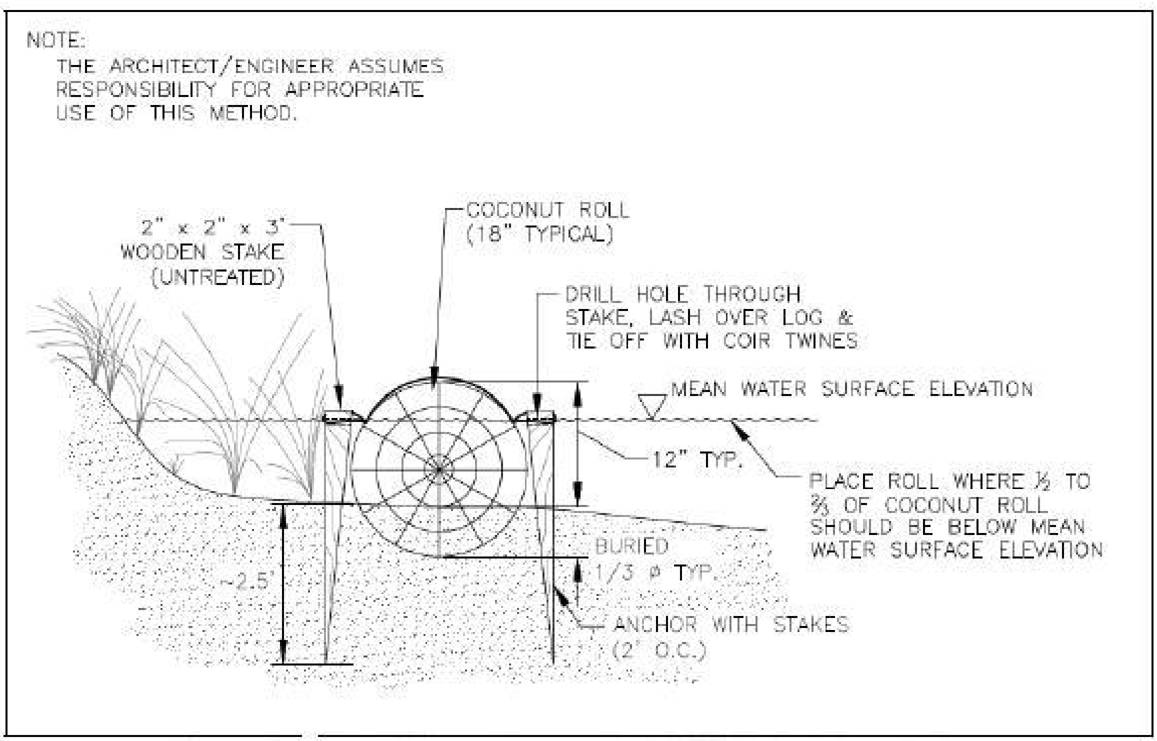


Figure 1.13-5b Offshore Coconut Roll (18” Typical) Installation

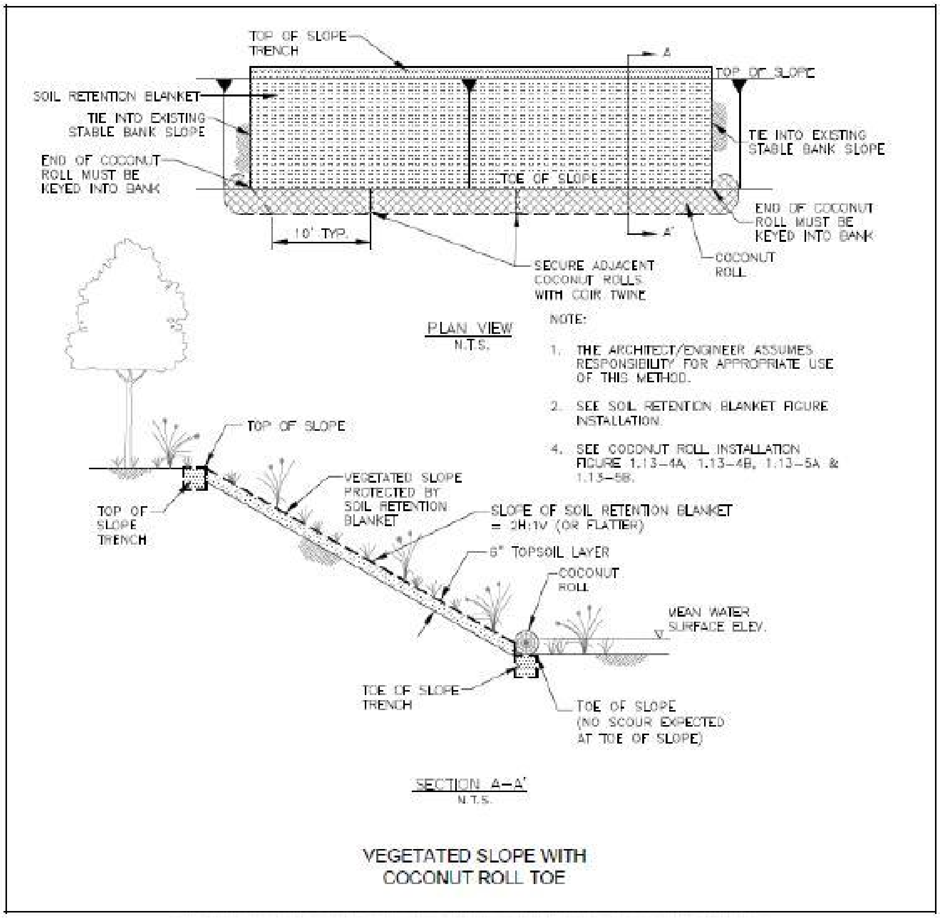


Figure 1.13-6 Vegetated Slope With Coconut Roll Toe

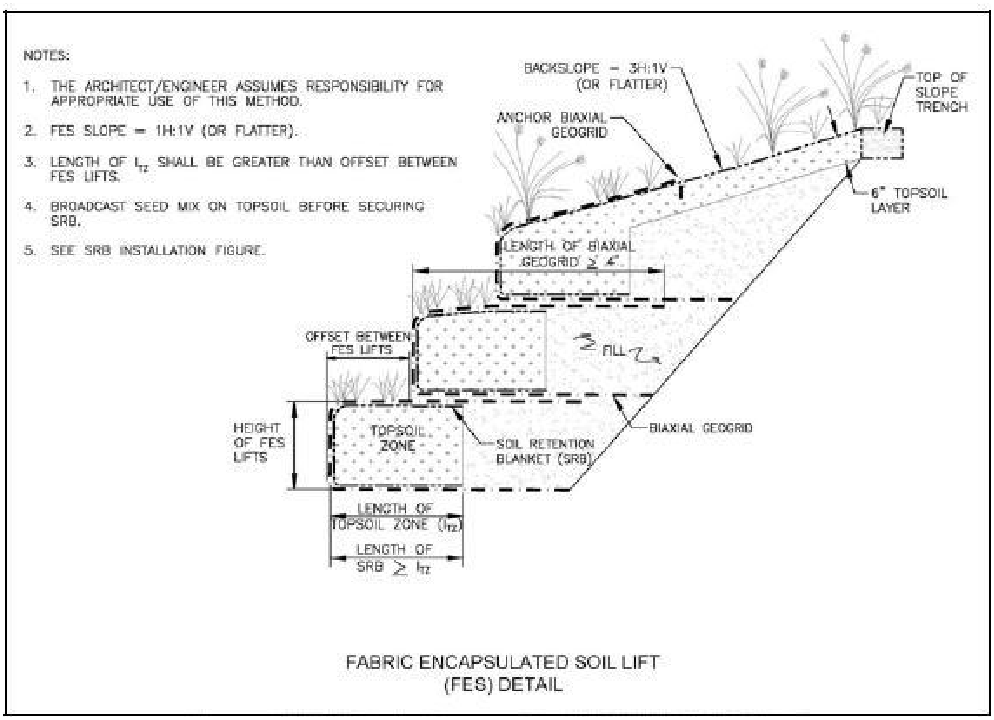


Figure 1.13-7 Fabric Encapsulated Soil Lift (FES) Detail

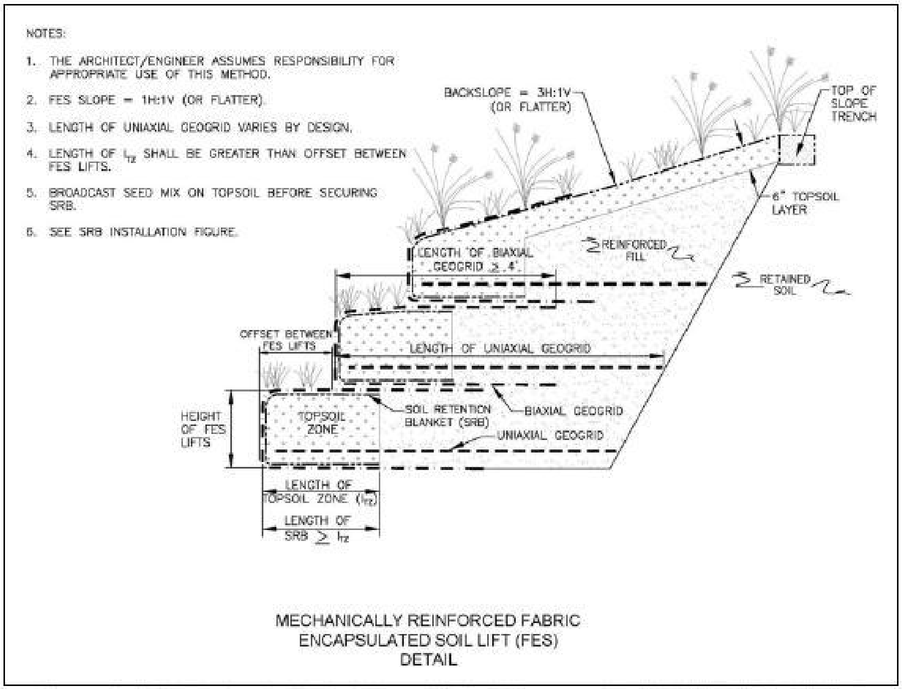


Figure 1.13-8 Mechanically Reinforced Fabric Encapsulated Soil Lift (FES) Detail

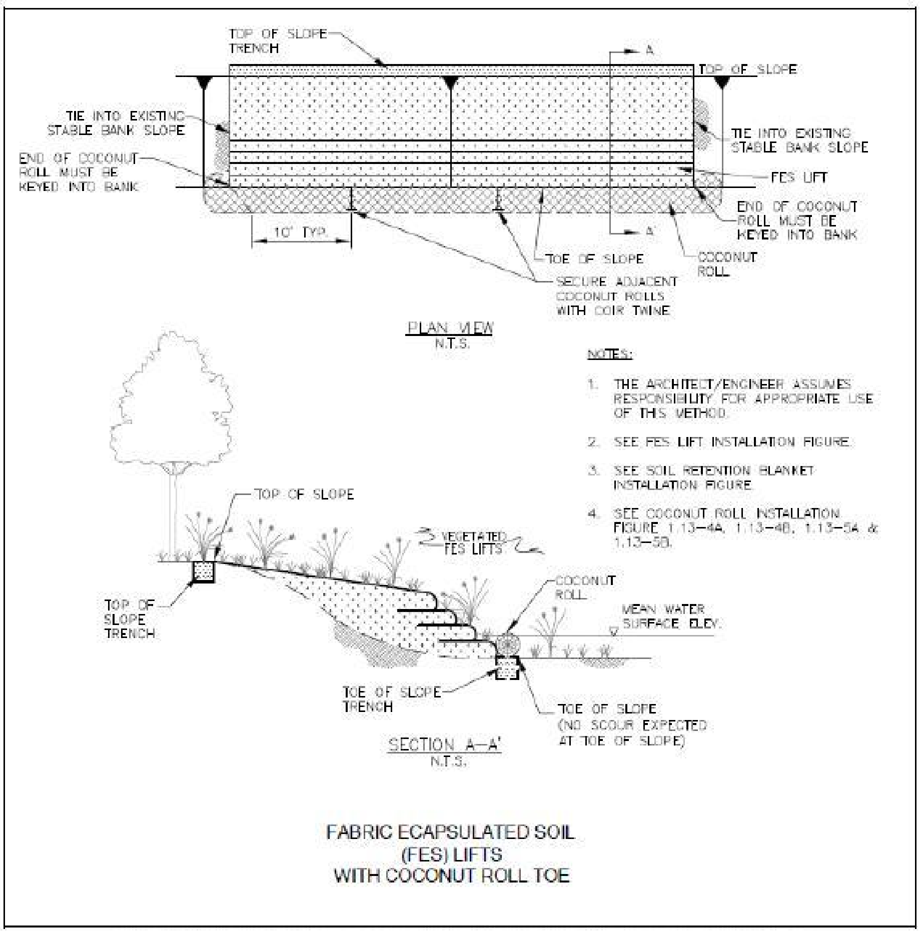


Figure 1.13-9 Fabric Encapsulated Soil Lifts with Coconut Roll Toe

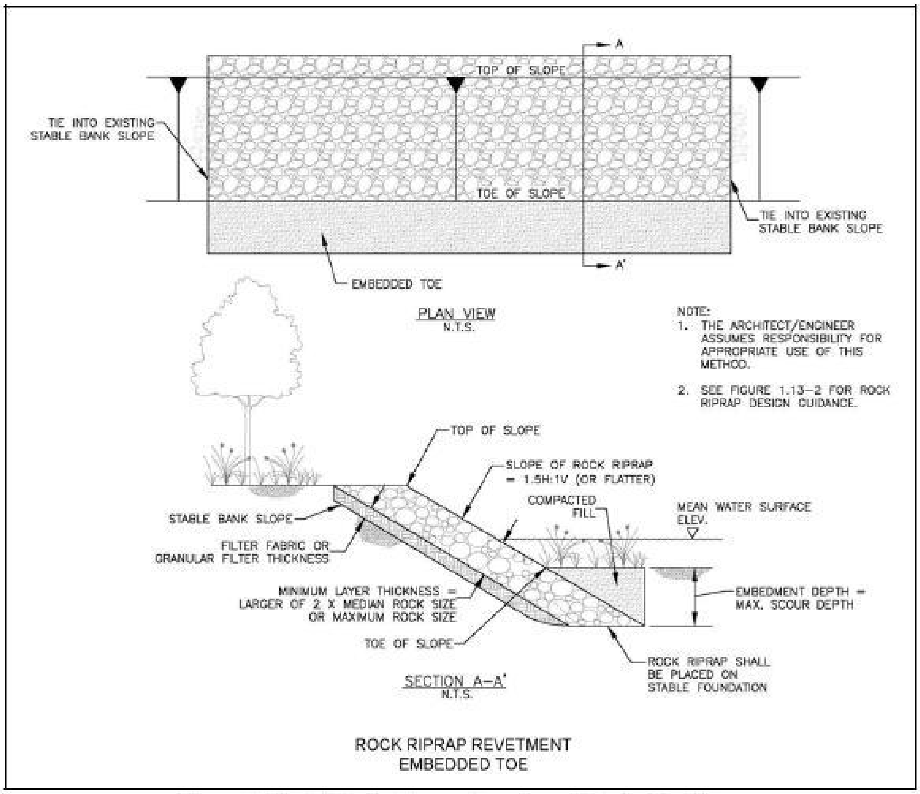


Figure 1.13-10 Rock Riprap Revetment Embedded Toe

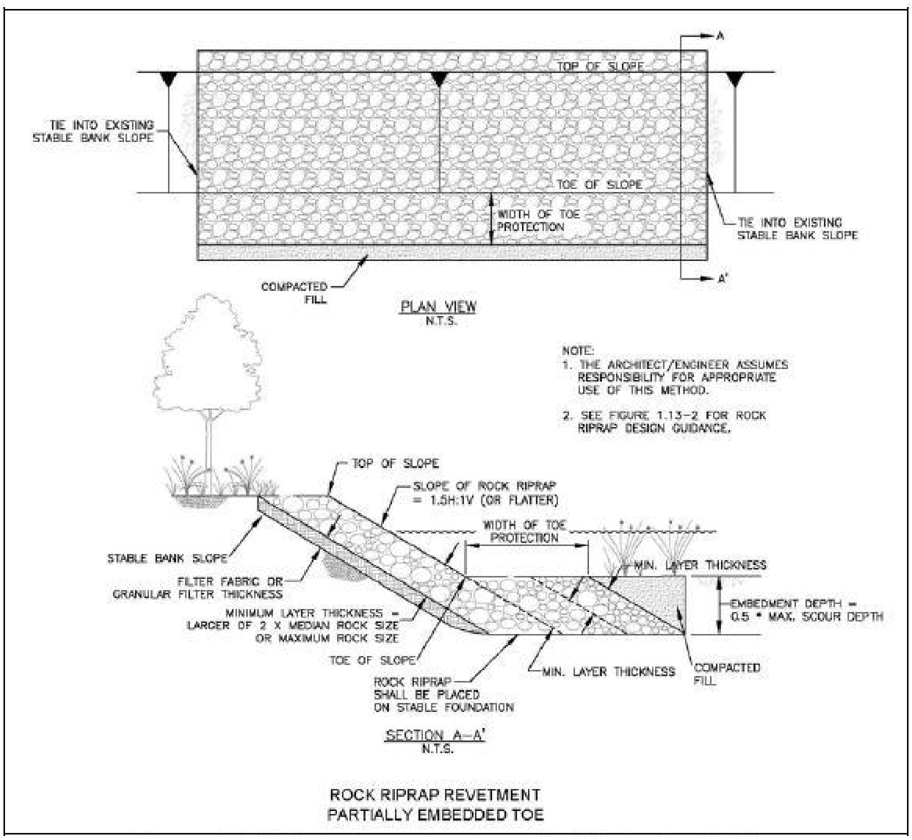


Figure 1.13-11 Rock Riprap Revetment Partially Embedded Toe

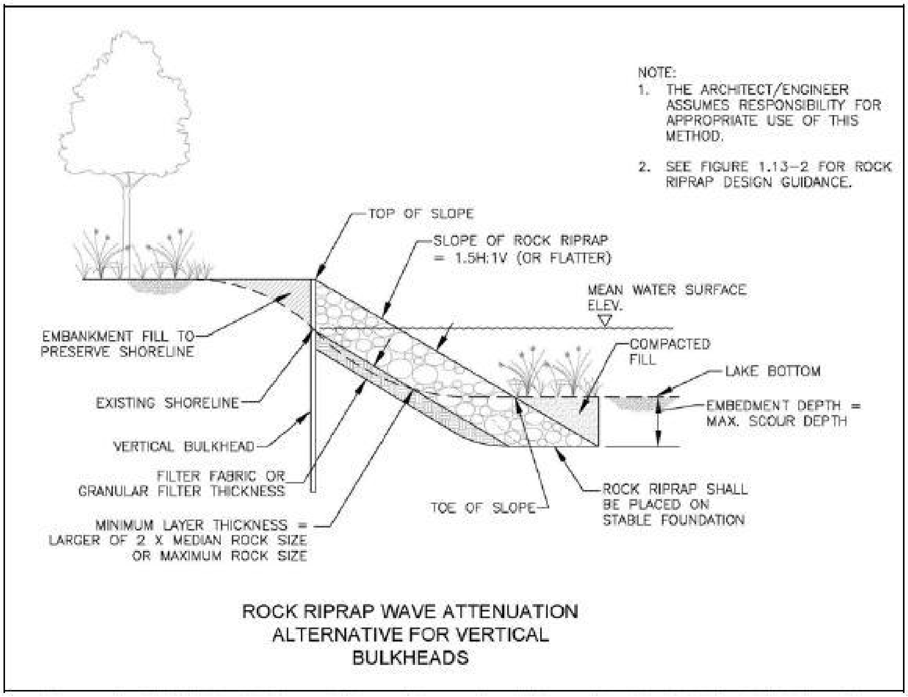


Figure 1.13-12 Rock Riprap Wave Attenuation Alternative For Vertical Bulkheads

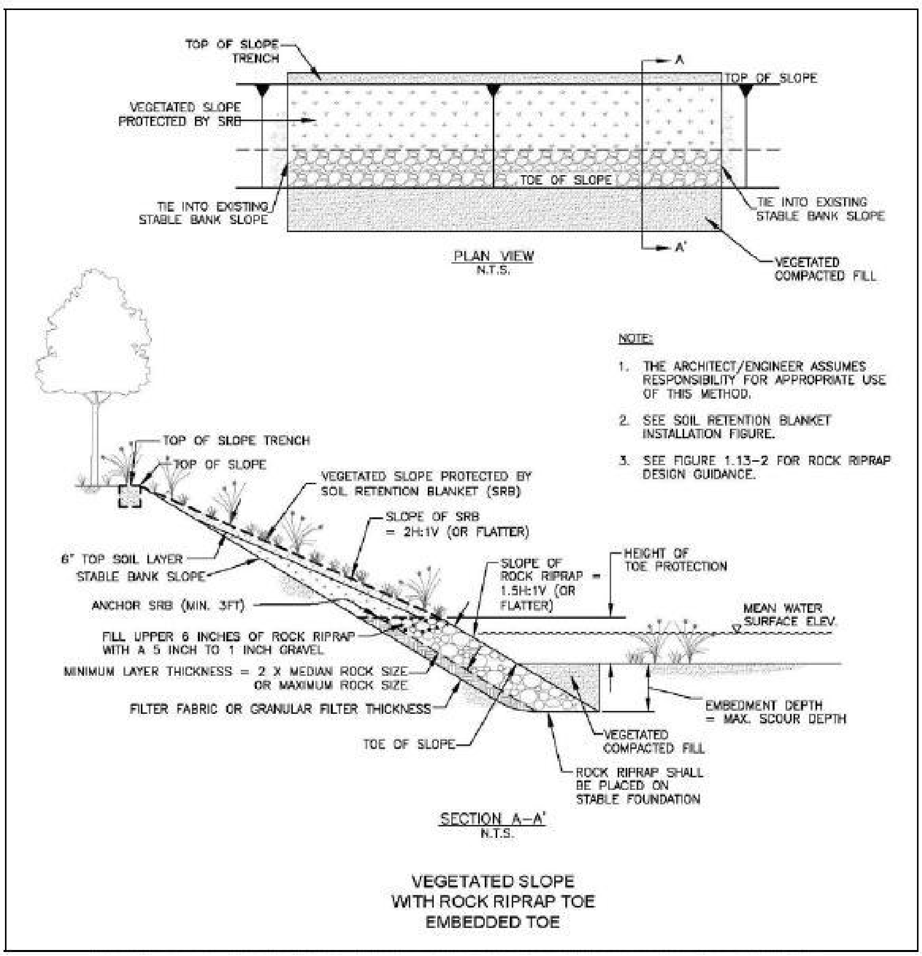


Figure 1.13-13 Vegetated Slope With Rock Riprap Toe Embedded Toe

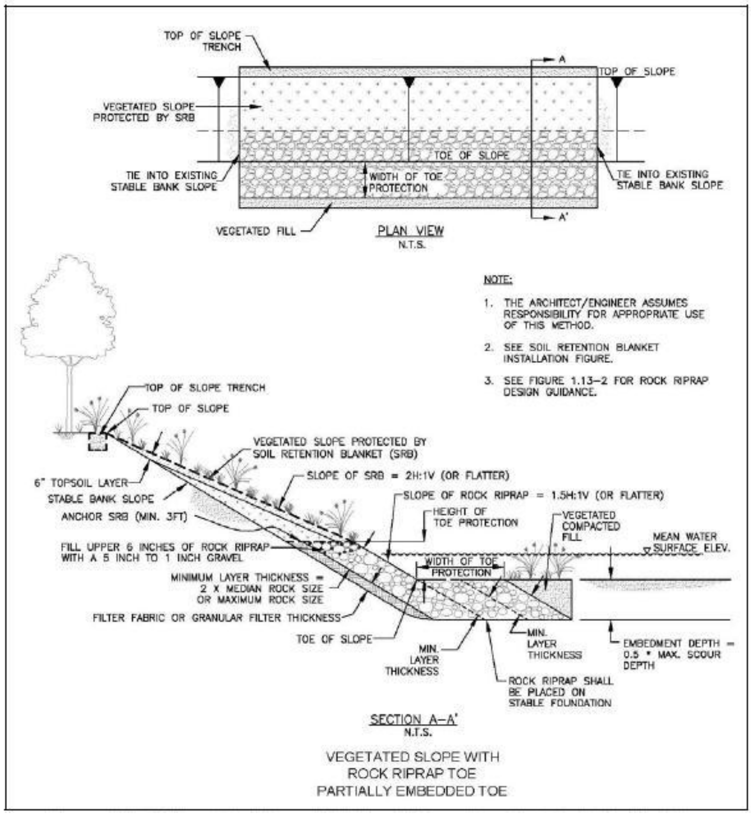


Figure 1.13-14 Vegetated Slope With Rock Riprap Toe Partially Embedded Toe

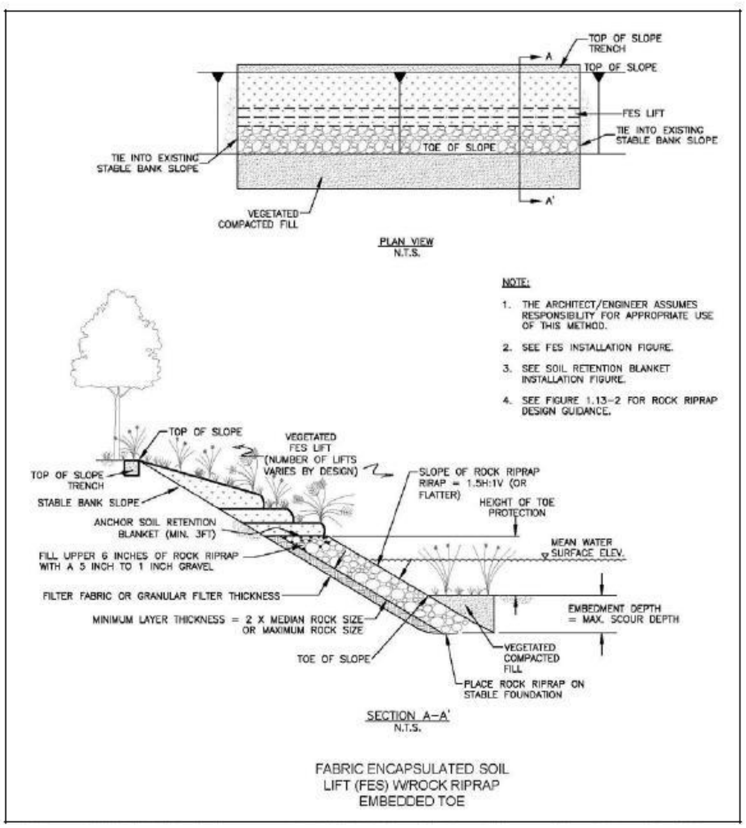


Figure 1.13-15 Fabric Encapsulated Soil Lifts with Rock Riprap Toe Embedded Toe

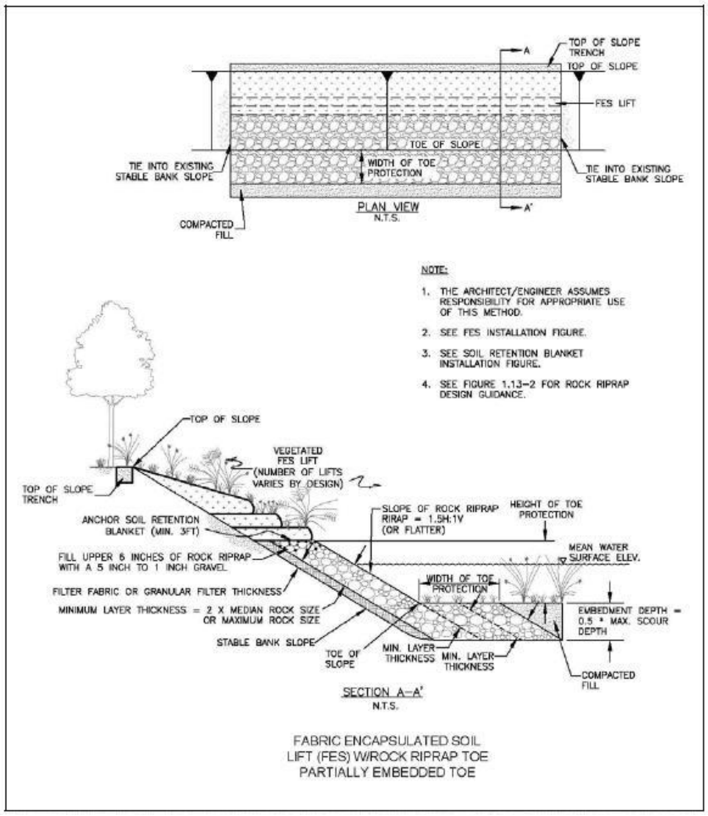


Figure 1.13-16 Fabric Encapsulated Soil Lifts with Rock Riprap Toe Partially Embedded Toe

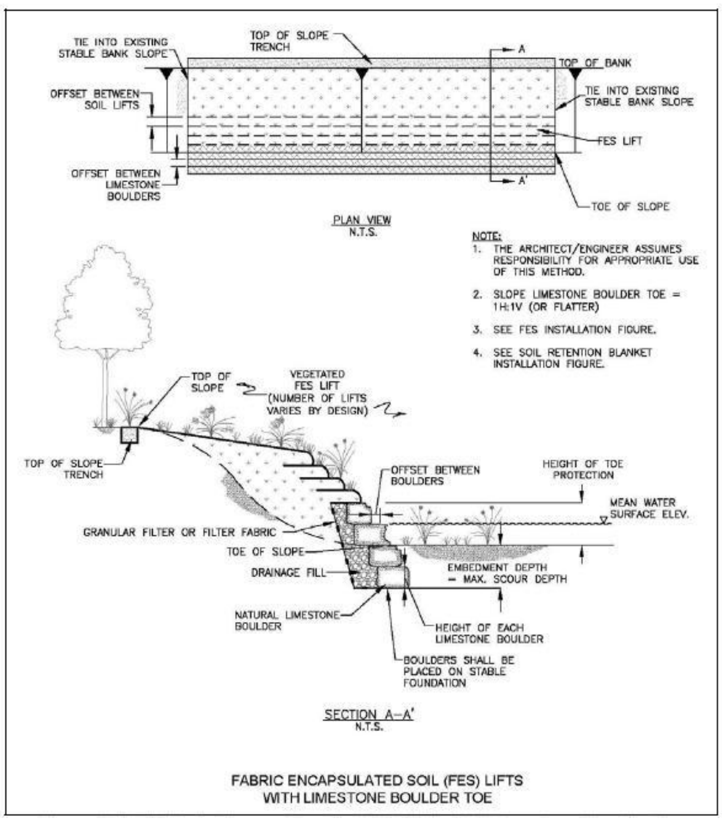


Figure 1.13-17 Fabric Encapsulated Soil (FES) Lifts With Limestone Boulder Toe

1.13.10 References

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